CHAPTER 3

RIGGING

Rigging is the application of fiber or wire rope in various tackle combinations used to raise or move loads. Rigging involves installing the necessary equipment to use the available effort, and it may or may not produce a mechanical advantage.

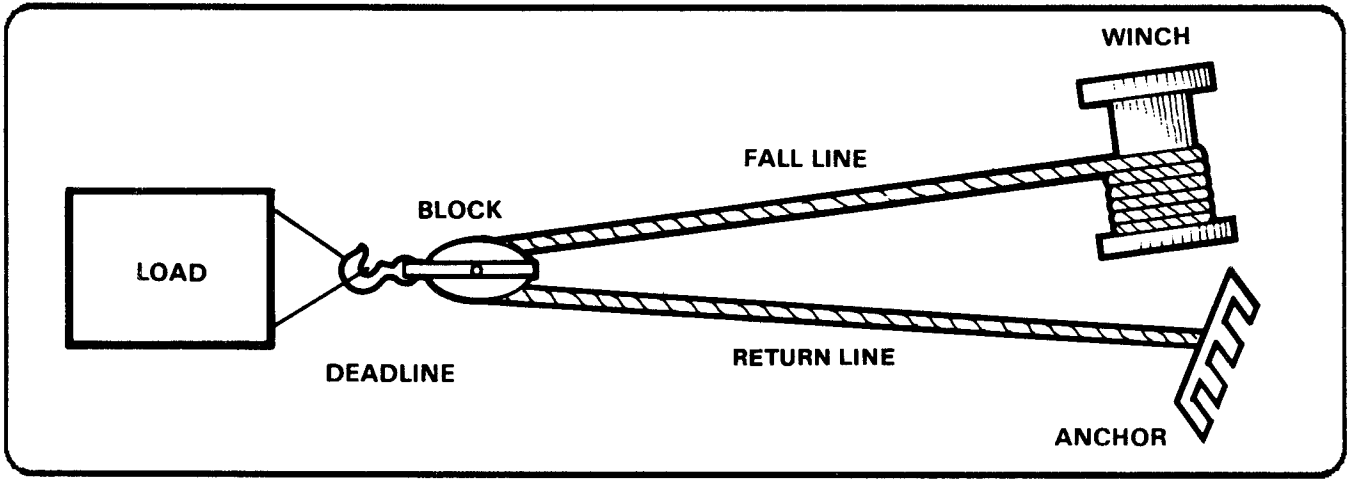

Figure 3-1. Terminology of Simple Tackle

RIGGING FUNDAMENTALS

FALL LINE

This is the winch line that runs from the source of effort to the first block in the tackle. There is only one fall line in a simple tackle system. The amount of force that must be exerted on the fall line relative to the available effort must be considered in every problem. To determine the fall line force, divide the total resistance by the mechanical advantage of the

tackle. The fall line force must be less than the capacity of the effort to accomplish the recovery. See Example in second section.

RETURN LINES

These are the winch lines between the blocks or the winch line from the sheave of a block to the point where the end of the line is attached. This force is always the same as the fall-line force.

DEAD LINES

These are lines used to attach blocks or other equipment to the load or to an anchor. To determine the dead line force, multiply the fall-line force by the number of winch lines supported by the dead line.

FLEET ANGLE

The achievement of even winding of the winch cable on the drum is important for wire rope life and winch operations. This is accomplished best by working with the proper fleet angle.

Illustration 3-2 shows the wire rope running from a fixed sheave, over a floating sheave, and then onto the surface of a smooth drum. The fleet angle is defined as the included angle between two lines; one line is drawn through the middle of the fixed sheave and the drum, and perpendicular to the axis of the drum. A second line is drawn from the flange of the drum to the base of the groove in the sheave. There are left and right fleet angles, measured to the left and right of the center line of the sheave.

Fleet angle should be restricted when wire rope passes over a fixed sheave and onto a drum. For the most efficient method and best service, the angle should not exceed 1 1/2 degrees.

MECHANICAL ADVANTAGE OF TACKLE

Mechanical advantage is needed whenever the load resistance is greater than the available effort. The amount of mechanical advantage needed is estimated by dividing the load resistance by the available effort. The mechanical advantage of any single tackle rigging is equal to the number of winch lines supporting the load or the number of winch lines that become shorter as power is applied to the winch.

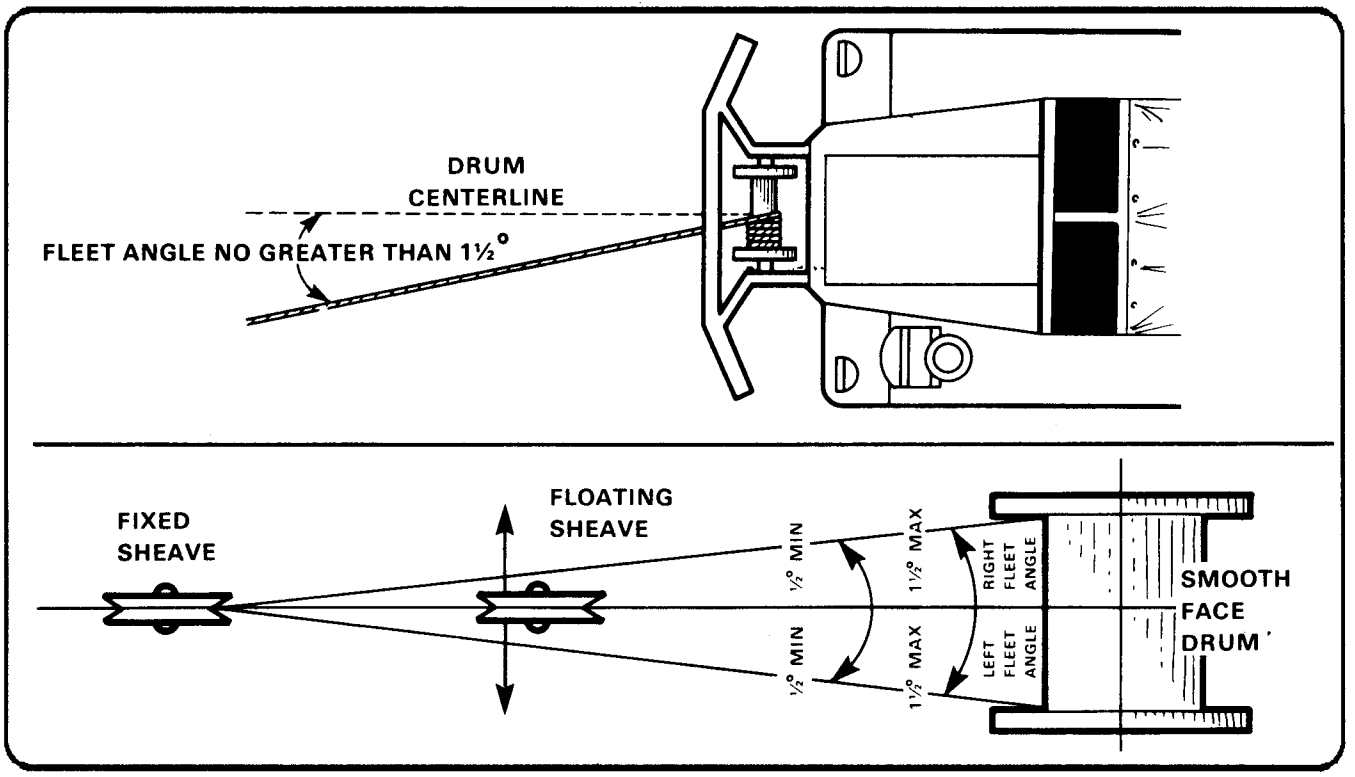

Figure 3-2. Fleet Angle

The lines can be attached directly or indirectly through a block.

TACKLE RESISTANCE

Friction created by a sheave rotating in its pin, the rope flexing around the sheave, or the rope scuffing in the groove of the sheave causes a loss in energy as

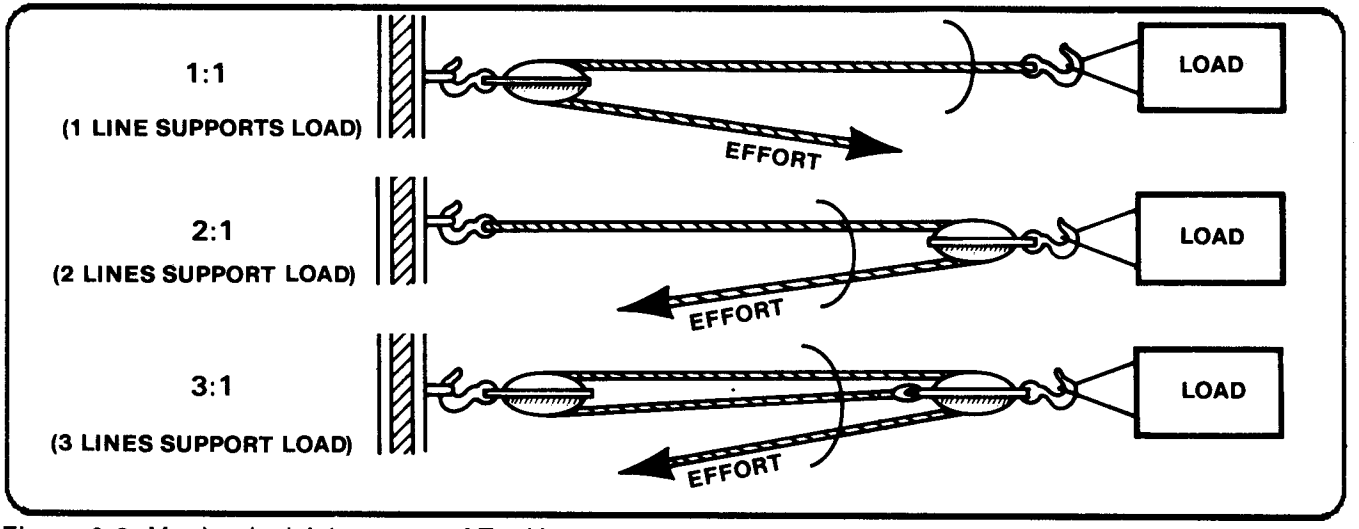

Figure 3-3. Mechanical Advantage of Tackle

FRICTION IN TACKLE CAUSES A LOSS IN ENERGY THAT MUST BE OVERCOME BEFORE THE LOAD RESISTANCE CAN BE MOVED

the rope passes around the sheave. This loss is resistance and must be overcome before the resistance of the load can be overcome. Each sheave in the rigging will create resistance. To determine tackle resistance, multiply 10 percent of the load resistance by the number of sheaves (not blocks) in the rigging.

Example: A load resistance of 20,000 pounds and a tackle with two sheaves (2 x 10 percent) are being used, therefore, 20 percent of 20,000 pounds equals 4,000 pounds tackle resistance.

TOTAL RESISTANCE

Since tackle resistance must be overcome before the load resistance can be moved, the load and tackle resistance are added. This resistance is total resistance (the total amount of resistance that the available effort must overcome).

Using the previous example of tackle resistance, the load resistance of 20,000 pounds, plus the tackle resistance of 4,000 pounds, equals a total resistance of 24,000 pounds.

DETERMINING LINE FORCES

The following example shows how to compute various line forces.

Example: A disabled vehicle had a load resistance of 14 tons (28,000 lb). The available effort (AE) is a winch with a maximum capacity of 5 tons (10,000 lb). What mechanical advantage (MA) must be rigged to recover this vehicle? What are the line forces?

- **STEP 1- Determine Initial Estimate**

$$\frac{\text{LOAD RESISTANCE}}{\text{AVAILABLE EFFORT}} = \text{REQUIRED MECHANICAL ADVANTAGE}$$

$$\frac{28{,}000\ (LR)}{10{,}000\ (AE)} = 2.8$$

REQUIRED MECHANICAL ADVANTAGE (MA) = 3

- **STEP 2- Verify Solution/Add Tackle Resistance**

An MA of 3 requires 2 sheaves; therefore, 2 x (10 percent per sheave) or 20 percent must be added to the load resistance.

$$28{,}000 + .20 \times 28{,}000 = 33{,}600$$

$$\frac{33{,}600\ (LR)}{10{,}000\ (AE)} = 3.36$$

REQUIRED MA = 4

This is not equal to the answer in step 1; therefore, you must reverify your answer.

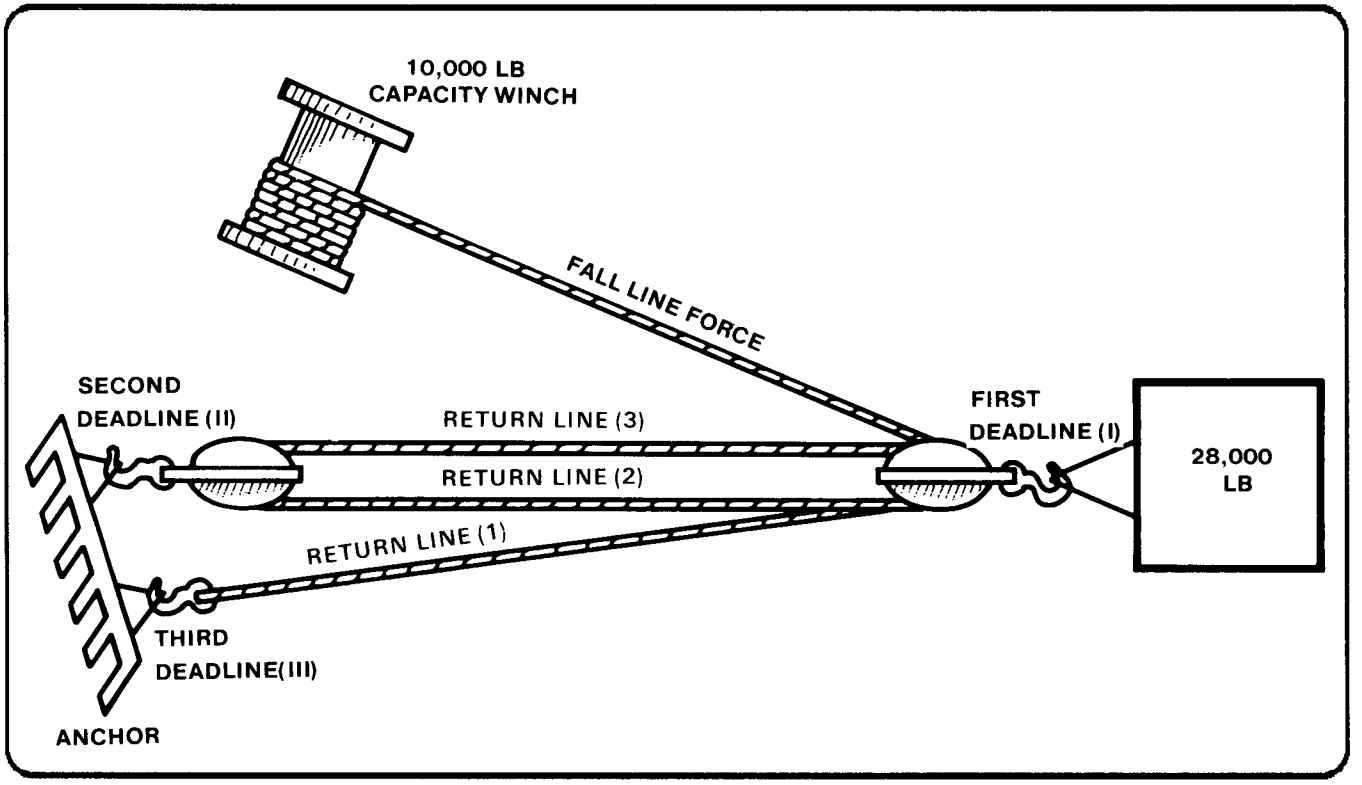

Figure 3-4. Line Forces

- **STEP 3- Reverify Solution**

A MA of 4 requires 3 sheaves. Therefore, 3 x (10 percent per sheave) or 30 percent must be added to the load resistance.

$$28{,}000 + .30 \times 28{,}000 = 36{,}400$$

$$\frac{36{,}400\ (LR)}{10{,}000\ (AE)} = 3.64$$

REQUIRED MA = 4

This is equal to the answer in step 2; therefore, you have reached a solution. Now determine all line forces.

- **STEP 4- Determine Line Forces**

a. Total resistance to overcome = load + tackle resistance. From the previous step, the total resistance is equal to 36,400 lb and the MA needed is 4.

NOTE: There is one sheave in block A and two in block B.

b. Fall line force:

$$\frac{\text{TOTAL RESISTANCE (LR)}}{\text{MA}} = \text{FALL LINE FORCE}$$

$$\frac{36{,}400}{4} = 9{,}100 \text{ lb}$$

Double Check: The fall line force is less than the winch capacity.

c. Return line force:

Return line force = Fall line force

Lines No 1, 2, and 3 = 9,100 lbs

d. Dead line Force:

Dead line force = number of supported winch lines x line force

DEAD LINE I = 4 x 9,100 lb = 36,400 lb
DEAD LINE II = 2 x 9,100 lb = 18,200 lb
DEAD LINE III = 1 x 9,100 lb = 9,100 lb

NOTE: If field expedient slings are used as dead lines, refer to TM 5-725 to determine sling leg forces. Field expedient slings are considered to be slings constructed using materiel not part of the recovery vehicle's BII.

RIGGING TECHNIQUES

The rigging techniques used depend on terrain, the type of vehicle, and the distance between the recovery vehicle and disabled vehicle.

MANPOWER METHOD

The manpower method is used when the winch cable and other rigging equipment are lightweight and can be carried easily by the crew members to where they are needed.

BACKUP METHOD

The backup method is used when the recovery vehicle can be safely positioned within 25 feet of the disabled vehicle. Pull out enough main winch cable to attach to the disabled vehicle. Place the main winch snatch block in the loop of the cable and attach the block to the disabled vehicle. Back up the recovery vehicle allowing the main winch cable to be spooled from the winch drum until sufficient cable is removed to obtain maximum winch capacity. The il-

lustration below shows the recovery vehicle in position to perform the winching operation.

LEAD METHOD

The lead method is used when terrain conditions do not permit close access to the disabled vehicle. Use the boom winch cable to pay out the main-winch rigging to the disabled vehicle. Since the hoist-winch cable weighs less than the main-winch cable, it can be carried to the disabled vehicle.

To rig for the lead method, assemble the main-winch tackle just in front of the recovery vehicle as in preparation for the backup method. Attach the hoist-winch cable to the main-winch snatch block;

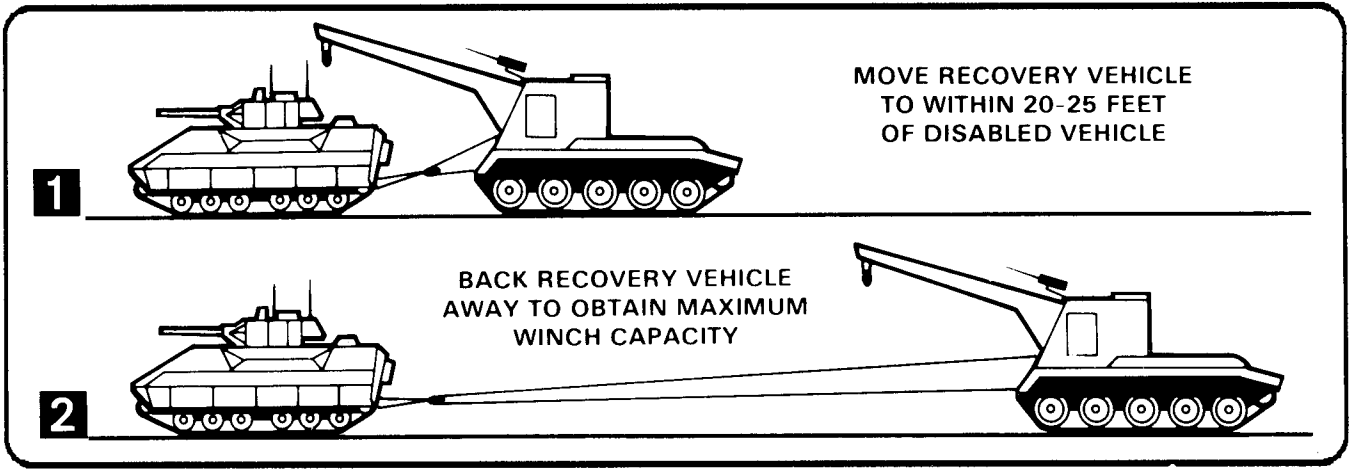

Figure 3-5. Backup Method of Rigging

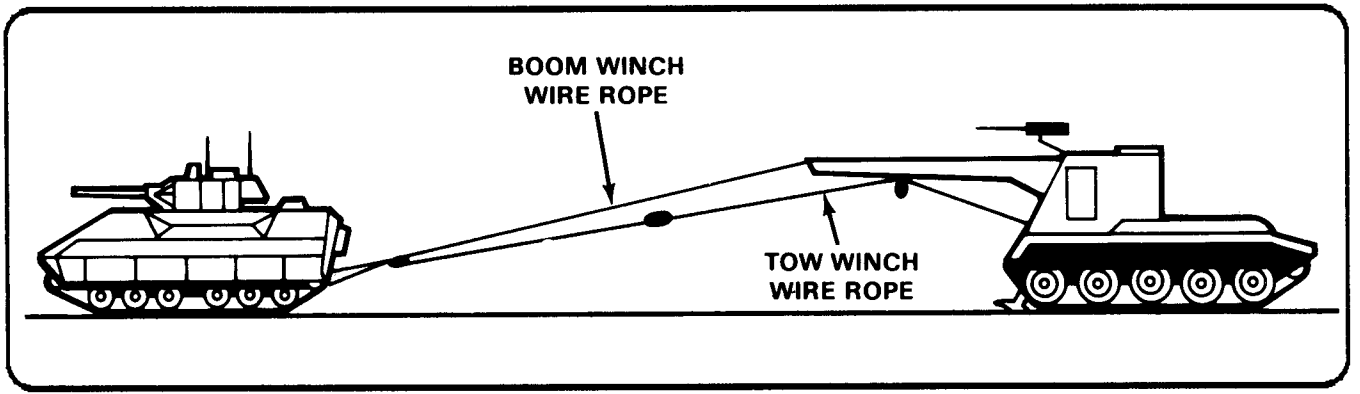

Figure 3-6. Lead Method of Rigging

then manually pull out the loop formed by the hoist-winch cable and place it into a snatch block that is attached to the disabled vehicle. By paying in the hoist-winch cable, the main-winch tackle will be pulled to the disabled vehicle.

METHODS OF ATTACHING TACKLE

In recovery operations, rig the tackle so no damage is done to the vehicle or equipment. For instance, on disabled wheel vehicles, attach the rigging (tackle) to the bumper lifting shackles on both sides

of the tow pintle. If the pulling force is attached only to one frame member, the truck frame could be pulled out of alignment.

CAUTION:

The pull on the tow pintle should not exceed what is specified in the operator's manual. Even though the bumper lifting shackles are designed to withstand force from a horizontal or vertical pull, a sling attachment must be used to apply the effort equally to both shackles. For vehicles not equipped with bumper lifting shackles, effort should be applied to the main structural members, not to the bumper or bumper brackets.

On wheel vehicles, whether the pull is made from the front or rear, apply the effort to both bumper lifting shackles or the tow pintle. The force exerted on each leg of the sling is slightly greater than half the resistance.

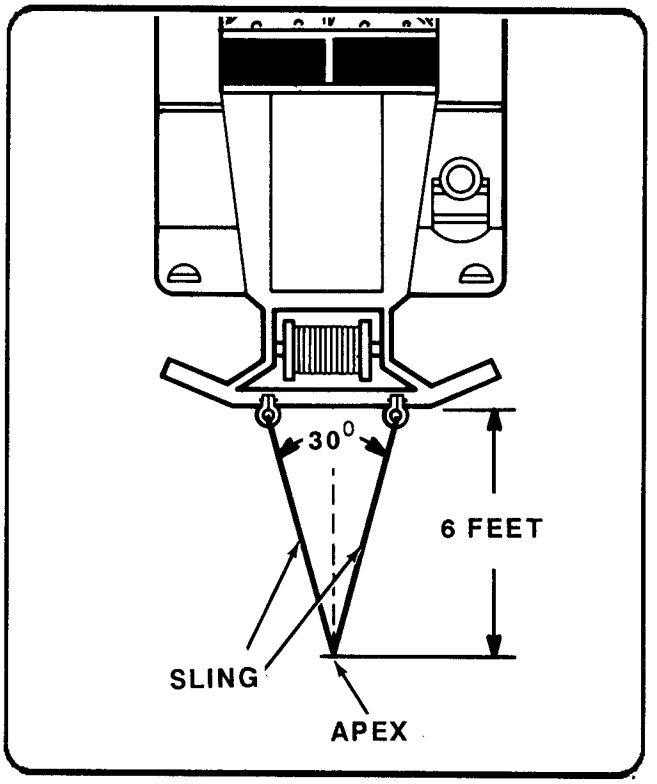

Figure 3-7. Sling Arrangement

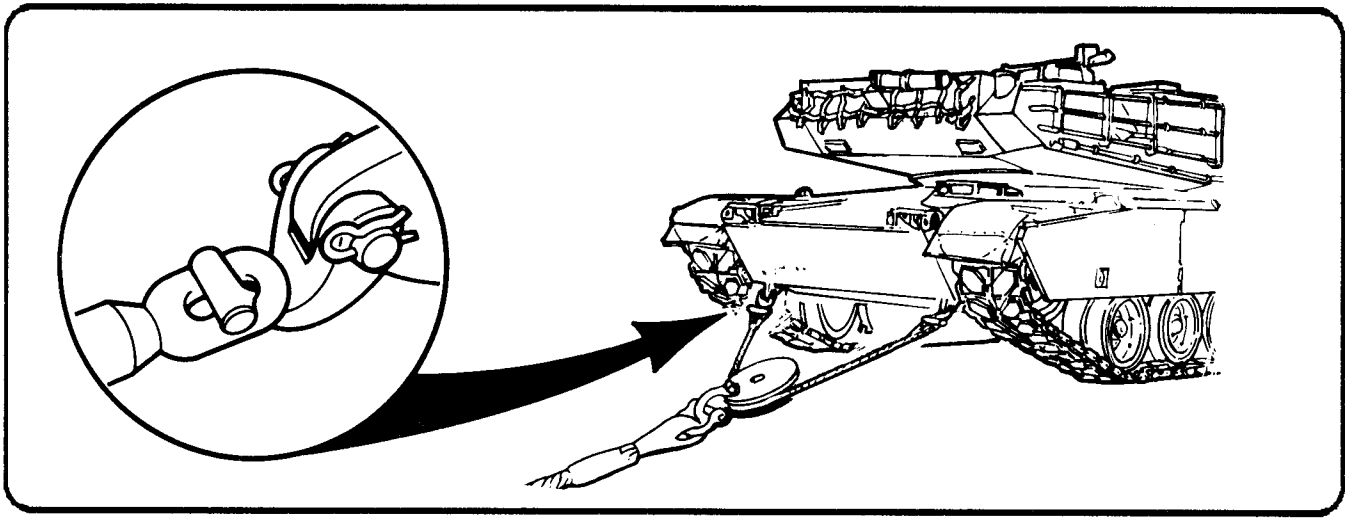

Figure 3-8. Floating Block Attachment

On track vehicles, always attach rigging to the tow hook or lugs. The lifting eyes are not designed to withstand the pulling force required for recovery. Use an attachment that will distribute the applied force to each side of the vehicle. If the vehicle requires towing after winching, time can be saved by using the same attachment.

When a disabled track vehicle does not require towing or mechanical advantage, use the main winch snatch block with one tow cable to form a floating block hookup. This hookup is easy to install and distributes the effort evenly to both tow hooks. To rig a floating block, attach the ends of the tow cable to the two tow hooks. Place the snatch block in the loop

formed by the tow cable. Attach the winch cable to the snatch block. Ensure cables and attachments can withstand forces.

When a disabled vehicle requires a 2:1 mechanical advantage rigging, and if towing over rough terrain after winching is required, use two tow cables to make the attachment. The attachment, illustrated above, is the quickest to rig.

When towing a vehicle over relatively level terrain or on highways, use the tow bar method of attachment. Attach the tow bar to the tow lugs of the disabled vehicle and attach the winch rigging to the lunette of the tow bar. After winching, disassemble the rigging and place the tow bar lunette in the recovery vehicle's tow pintle.

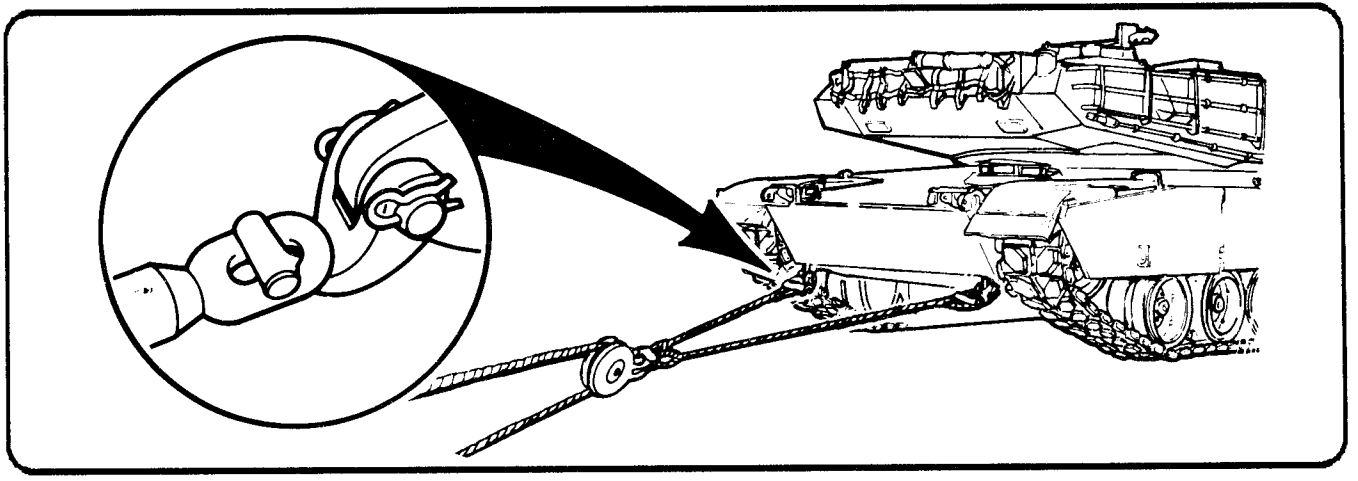

Figure 3-9. Tow Cable Attachment

If a 3:1 mechanical advantage is required, attach the running block to one of the tow lugs of the disabled vehicle, the change-of-direction block to the tow lug on the recovery vehicle, and the end of the winch cable to the other tow lug on the disabled vehicle.

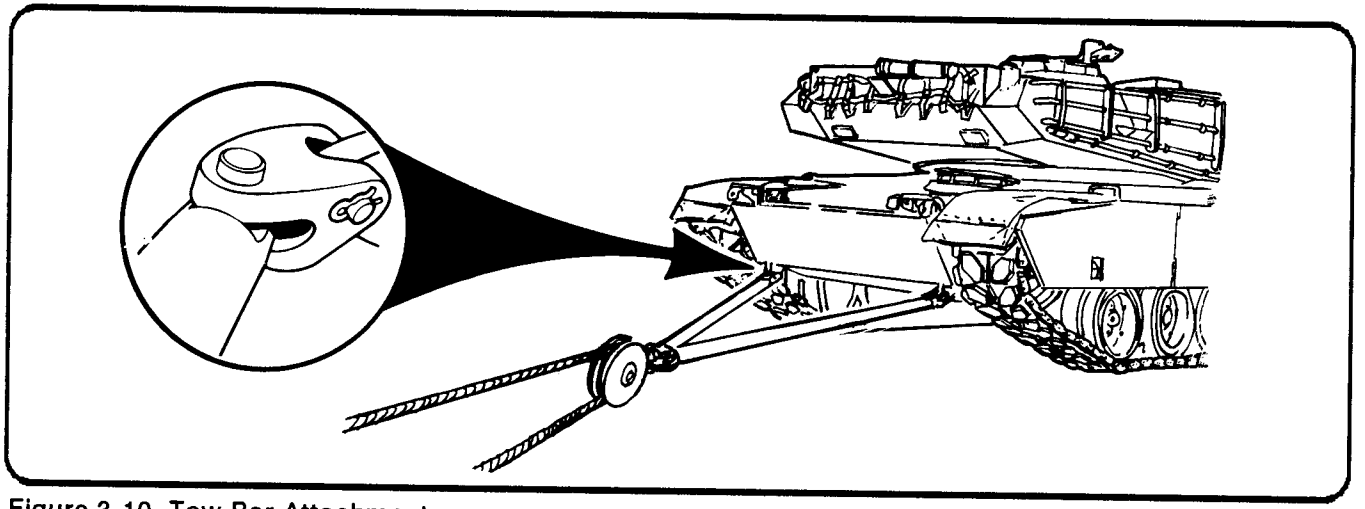

Figure 3-10. Tow Bar Attachment

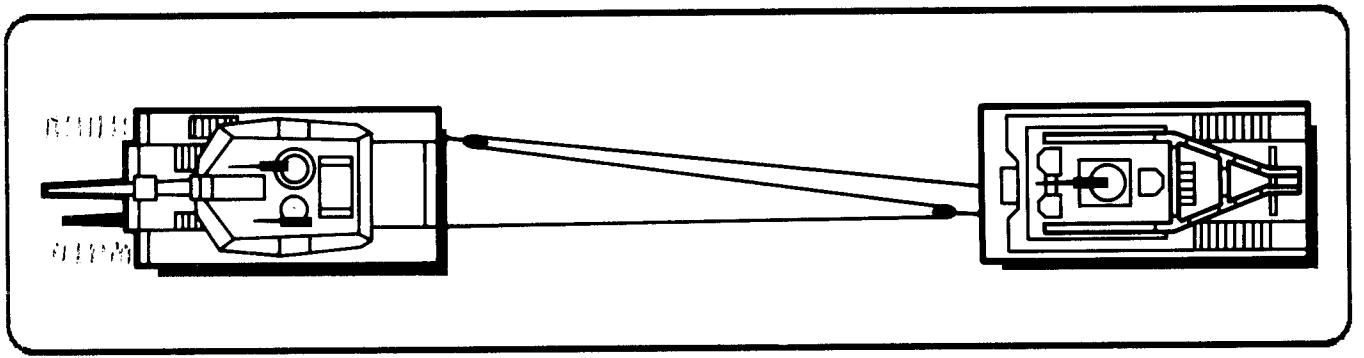

Figure 3-11. 3:1 Mechanical Advantage

ANCHORS

USE OF ANCHORS

Frequently, wheel and track vehicles must have some anchoring means when winching heavy loads with tackle. An anchor can assist in holding a recovery vehicle, improvising a change of direction pull, or supporting part of the load during a winching operation. Most existing recovery vehicles have ground chocks or spades.

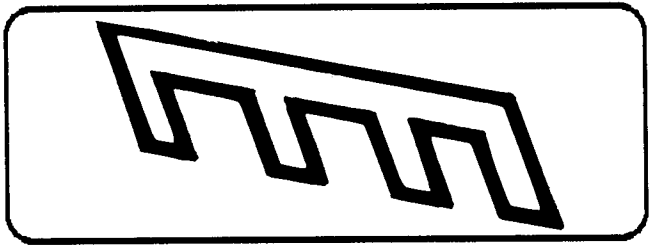

Figure 3-12. Anchor Symbol

TREES, TREE STUMPS, LARGE ROCKS, OR OTHER VEHICLES MAY BE USED AS ANCHORS IN RECOVERY OPERATIONS

NATURAL ANCHORS

An anchor that does not have to be constructed is a natural anchor. Examples are trees, tree stumps, and large rocks or other vehicles. Avoid dead or rotten trees or tree stumps, and examine rocks and trees carefully to make sure they are large enough and embedded firmly in the ground.

MECHANICAL ANCHORS

There are several types of mechanical anchors. The type constructed depends on holding ability requirements, type of soil, availability of material, and the situation.

Log Deadman

A log deadman is one of the best types of anchors for heavy loads. The deadman consists of a log buried in the ground with the dead line connected to it's center. When constructing a deadman, place it where the direction of pull is as horizontal as possible. Take advantage of sharp banks or crests to increase the holding power with less digging. Dig a trench large enough for the deadman and as deep as necessary for good bearing. When digging, slant the trench in the

direction of the pull at an angle of about 15° from the vertical. To strengthen the anchor, drive stakes in front of the deadman at each end. Dig a narrow inclined trench for the dead line at the center of the deadman. Tie the dead line to the center of the deadman so that the main or standing part of the line leads from the bottom of the deadman. This prevents the deadman from rotating out of the trench. If the dead line has a tendency to cut into the ground, place a small log under the line at the outlet of the trench. The strength of the deadman depends on the strength of the log and the holding power of the earth.

Picket Holdfasts

A picket holdfast is constructed by using two or more sound wooden pickets at least 3 inches in diameter and 5 feet long. Drive the pickets about 3 feet into the ground, 3 to 6 feet apart, and in line with

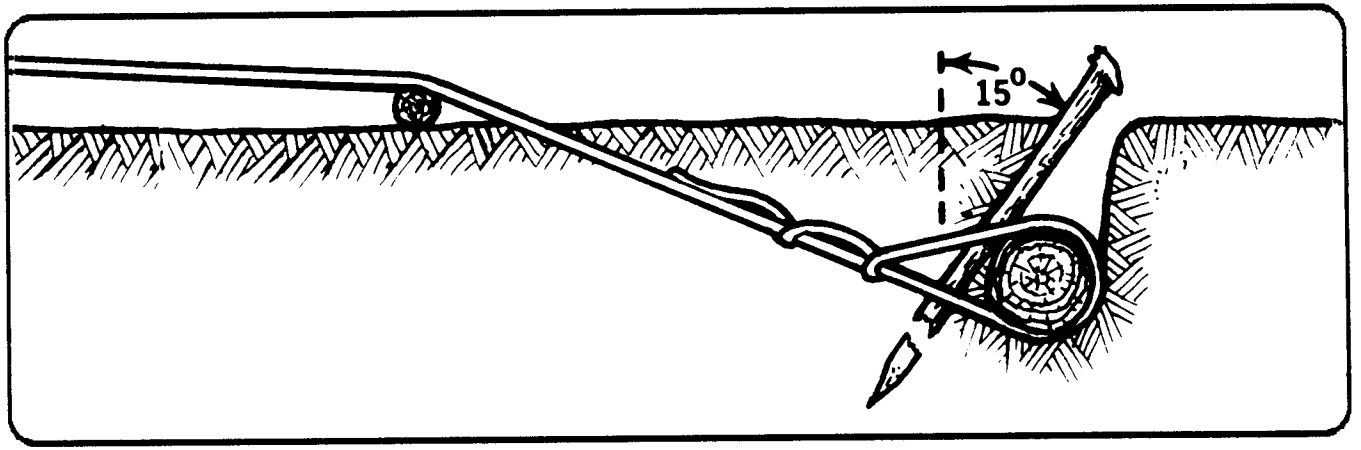

Figure 3-13. Log Deadman

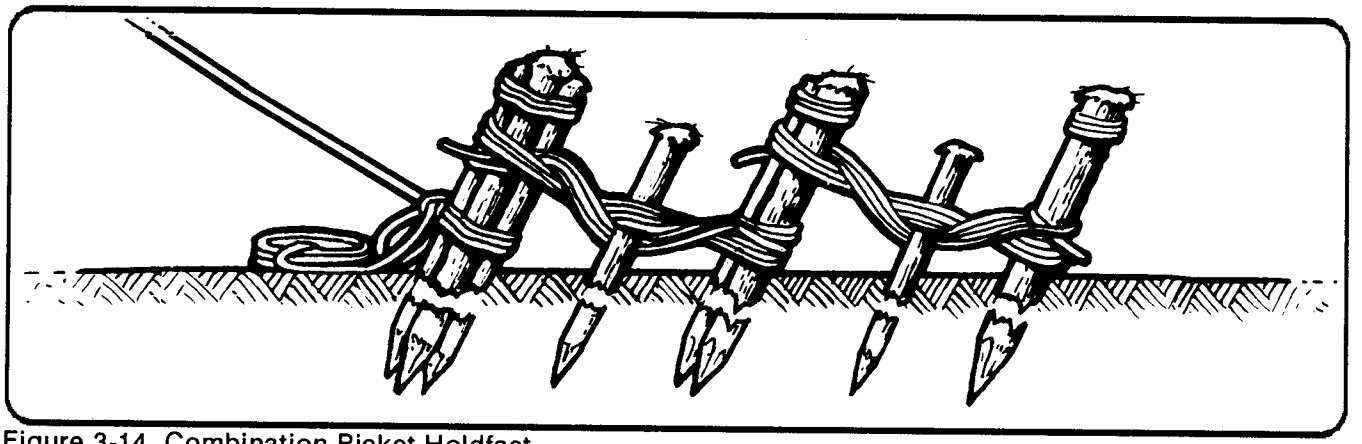

Figure 3-14. Combination Picket Holdfast

the dead line. Tie the pickets together with fiber rope by first tying one end of the rope to the top of the front picket with a clove hitch. Then make four to six wraps of the rope, starting from the top of the front picket to the bottom of the rear pickets, and tie the other end of the rope to the bottom of the rear picket with a clove hitch. Finally, pass a stake between the rope wraps midway between the pickets. Tighten the rope by twisting it with the stake, and then drive

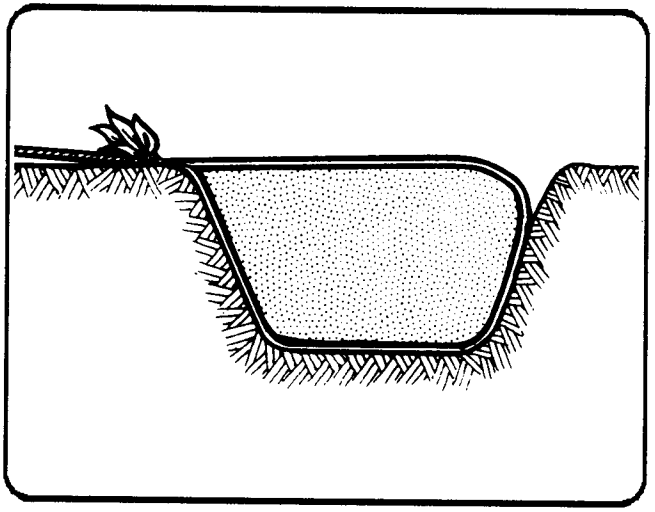

Figure 3-15. Sand Parachute

stake into the ground. Repeat this operation for each successive pair of pickets.

The strength of the holdfast depends on the first or front picket. To reinforce it, drive two or more pickets into the ground close to the front picket. Tie them together before tying to the rear picket.

Sand Parachute

A sand parachute is used as an anchor in a sandy area with no trees. Dig a large deep hole and line it with a tarpaulin. Fill the tarpaulin with the sand removed from the hole, lash the four corners together, and attach the rigging. The sand parachute has limited holding ability and should not be used when a major effort is required.

Scotch Anchor

A Scotch anchor is used to anchor a truck during winching operations when natural anchors are not available. Select a log at least 6 inches in diameter and 2 feet wider than the vehicle. Dig a shallow trench about 3 or 4 inches deep parallel to the front axle, just ahead of the front wheels. Then, lay a tow chain across the center of the trench, place the log in the trench, and move the vehicle forward until both front tires are against the log. Finally, attach both chain ends to the bumper lifting shackles, and remove all slack from the chain.

As pressure is applied to the winch, the front wheels are pulled onto the log, making the chain taut

and anchoring the vehicle. If more than one tow chain is available, a similar method may be used. Lay two tow chains across the trench next to the inside of each front wheel. Place the log in the trench, and move the vehicle forward until both front wheels are against the log. Then, wrap the chains through the bumper lifting shackles, remove slack from the chains, and fasten them together.

Vehicle

A vehicle can be used as an anchor to assist in the recovery of a mired vehicle equipped with a winch. The winch cable is payed out to the anchoring vehicle and the mired vehicle winches itself out. The anchoring vehicle should not attempt to pull; it is only an anchor.

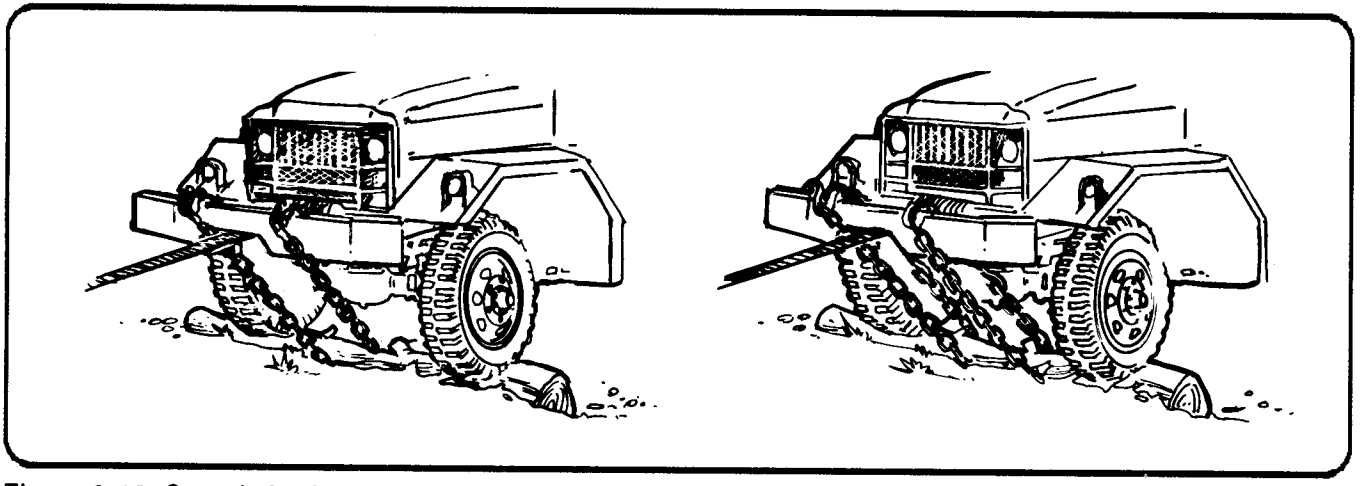

Figure 3-16. Scotch Anchors